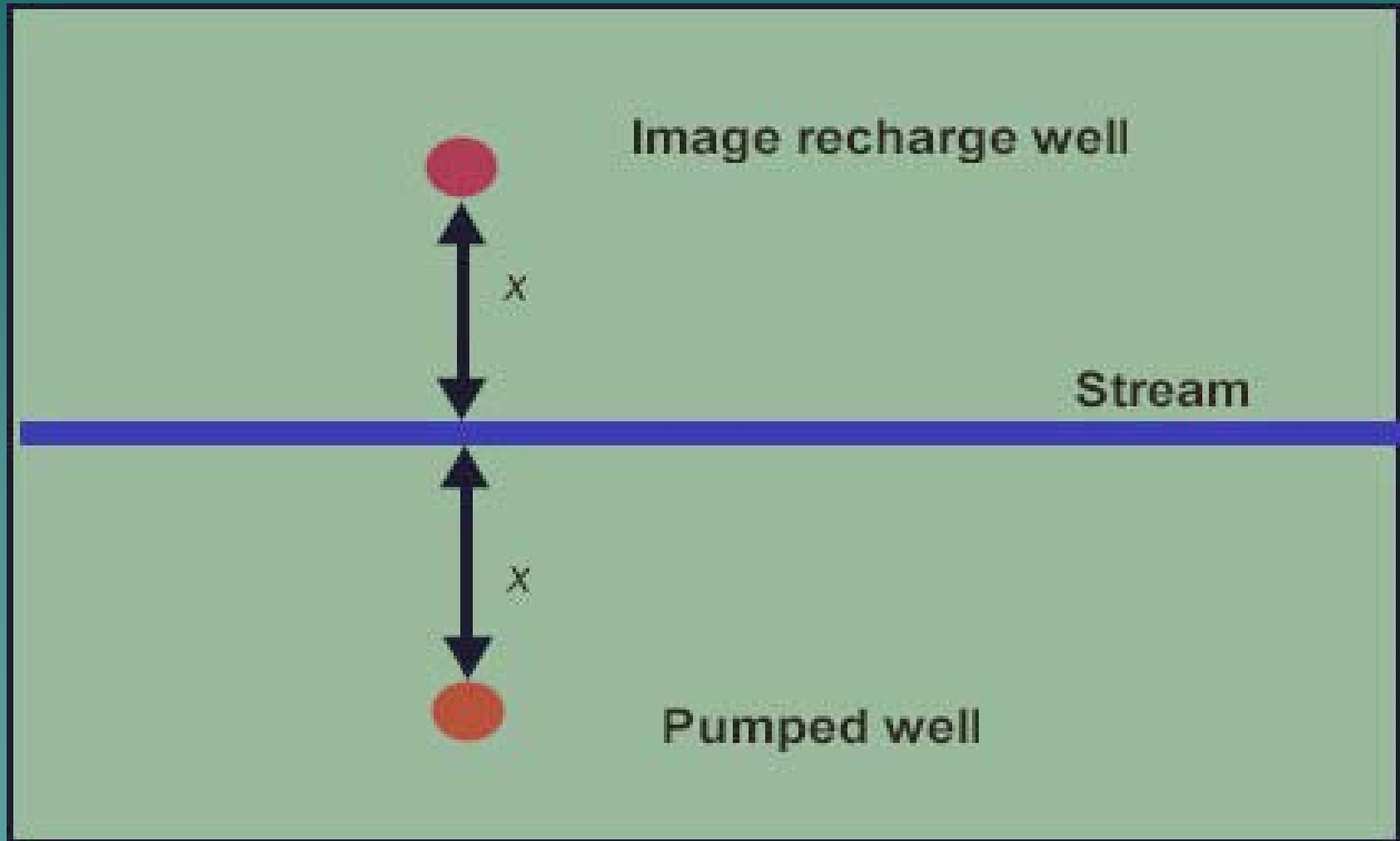


Analytic Vs Numeric Ground Water Models

Ray R. Bennett, PE
Colorado Division of Water
Resources

Example Analytic (Glover) Application



Analytic (Glover)

- ◆ Depletion (q) is a function of:
 - Pumping (Q)
 - Transmissivity (T)
 - Specific Yield (S_y)
 - Distance from well to river (x)
 - Distance to Aquifer Boundary (w)
- ◆ Data is assigned by Aquifer (1 value)
- ◆ RELATIVELY SIMPLE

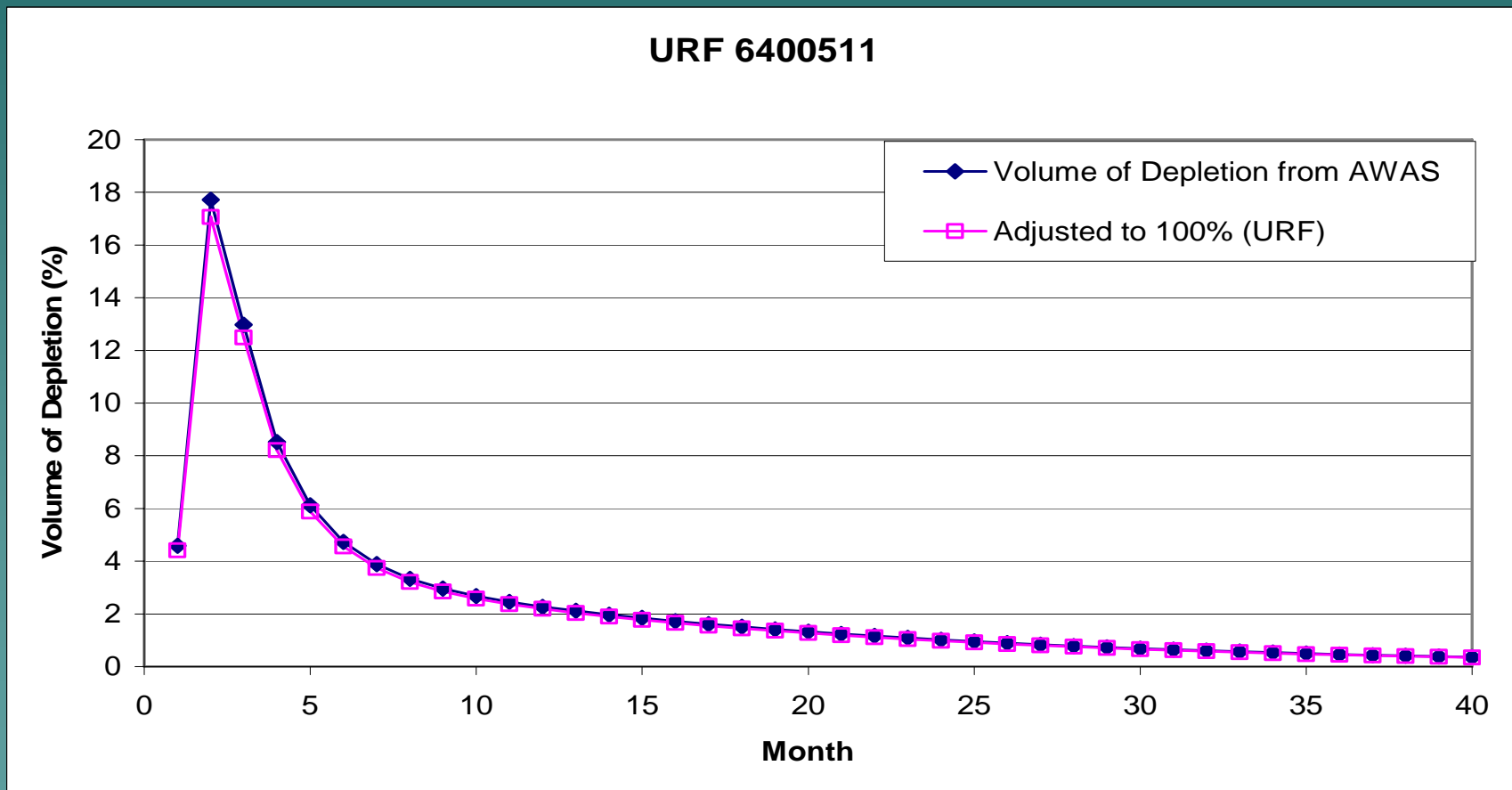
Analytical (Glover)

Key Assumptions

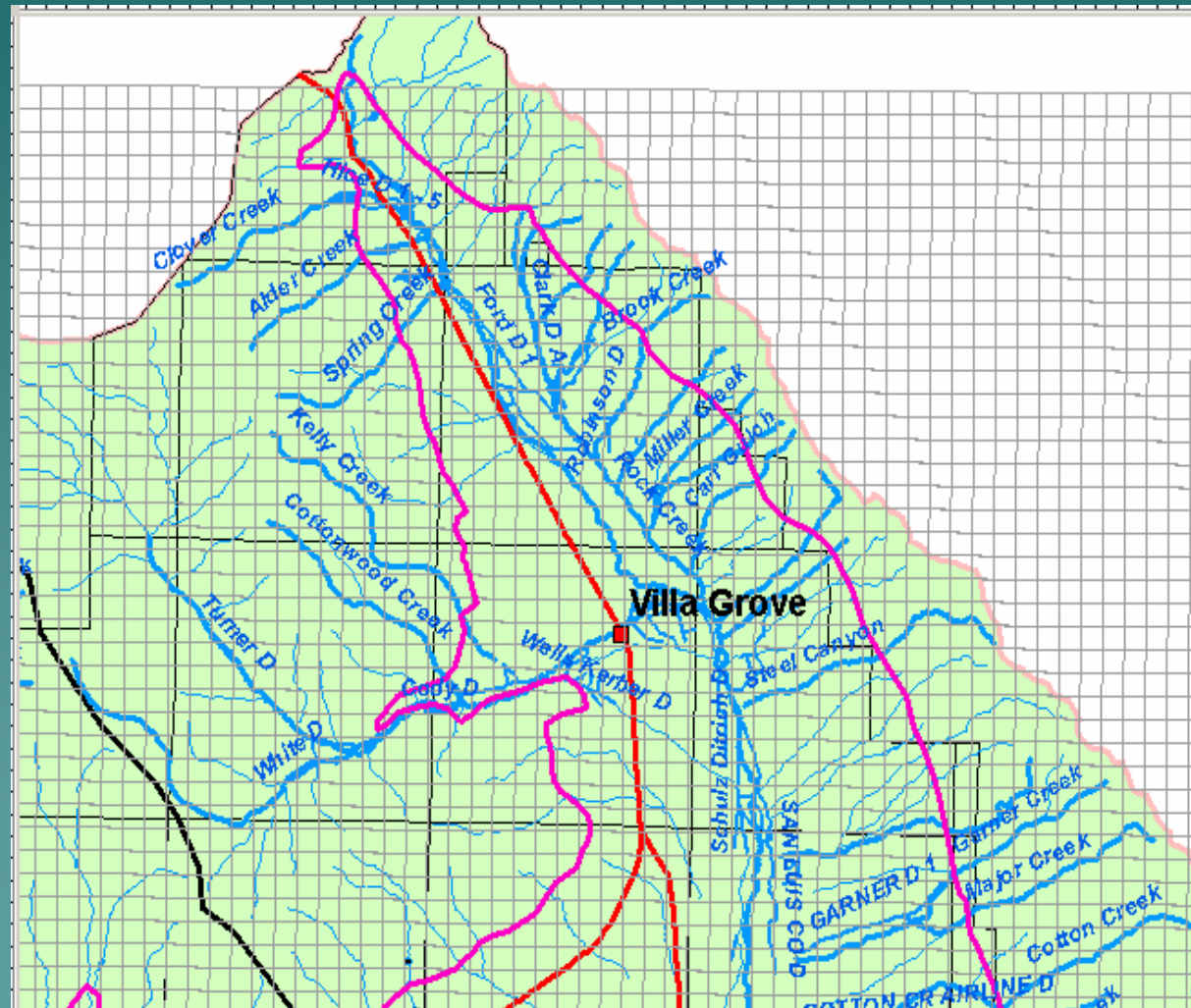
- ◆ Conductivity (K) is Constant
- ◆ Uniform Aquifer Thickness
 - Transmissivity is Constant
- ◆ Flat Water Table
- ◆ Stream is Fully Penetrating

Analytical (Glover) Results

Response from Pumping in Month 1 Only



Example Numeric Model

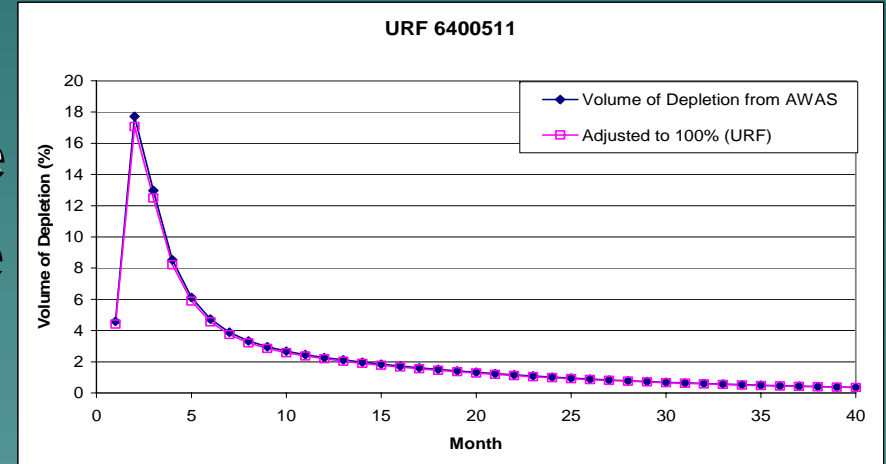


Numerical (Modflow) Model

- ◆ Depletion is still a function of:
 - Pumping (Q)
 - Hydraulic Conductivity (K)
 - Aquifer Thickness (b)
 - Specific Yield (S_y) or Storage Coefficient (S)
 - Distance from well to river (x)
 - Distance to Boundary (w)
- ◆ Data is assigned by Model Cell (1,000's)
- ◆ Might include complex geometry, multiple layers, boundary conditions, partially penetrating streams, ET from GW, subirrigation, impact on canals,
- ◆ LOTS of WORK

Numerical (Modflow) Results

- ◆ Stream Depletion
 - By stream Reach (not a point)
- ◆ Water Levels
- ◆ Ground Water Balance
- ◆ Stream Water Balance
 - Phreatophyte CU
 - Subirrigation
 - Complex Geology (faulting)
 - Complex Boundaries
 - Multiple, Layered Aquifers

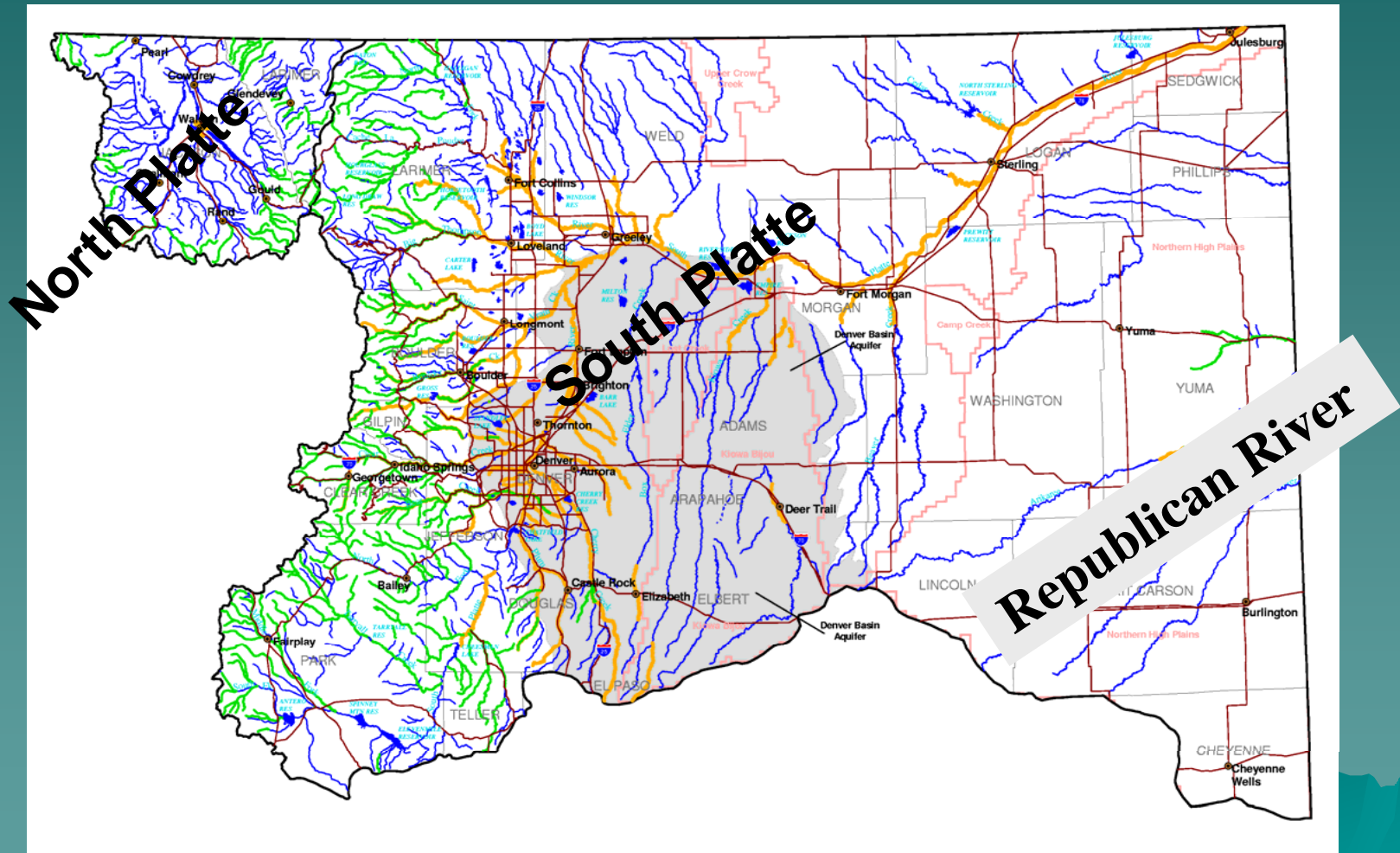


Comparison Summary

Item	Analytical	Numerical
Stream Depletion	Yes	Yes
Assumptions	High	Low-High
Water Levels	No	Yes
Complex Geology	No	Yes
Dry Stream	No	Yes
Multiple Aquifers	No	Yes
Effort	Low	Med-High

South Platte DSS


Division 1 except Republican (WD 65) and North Platte (WD 47)



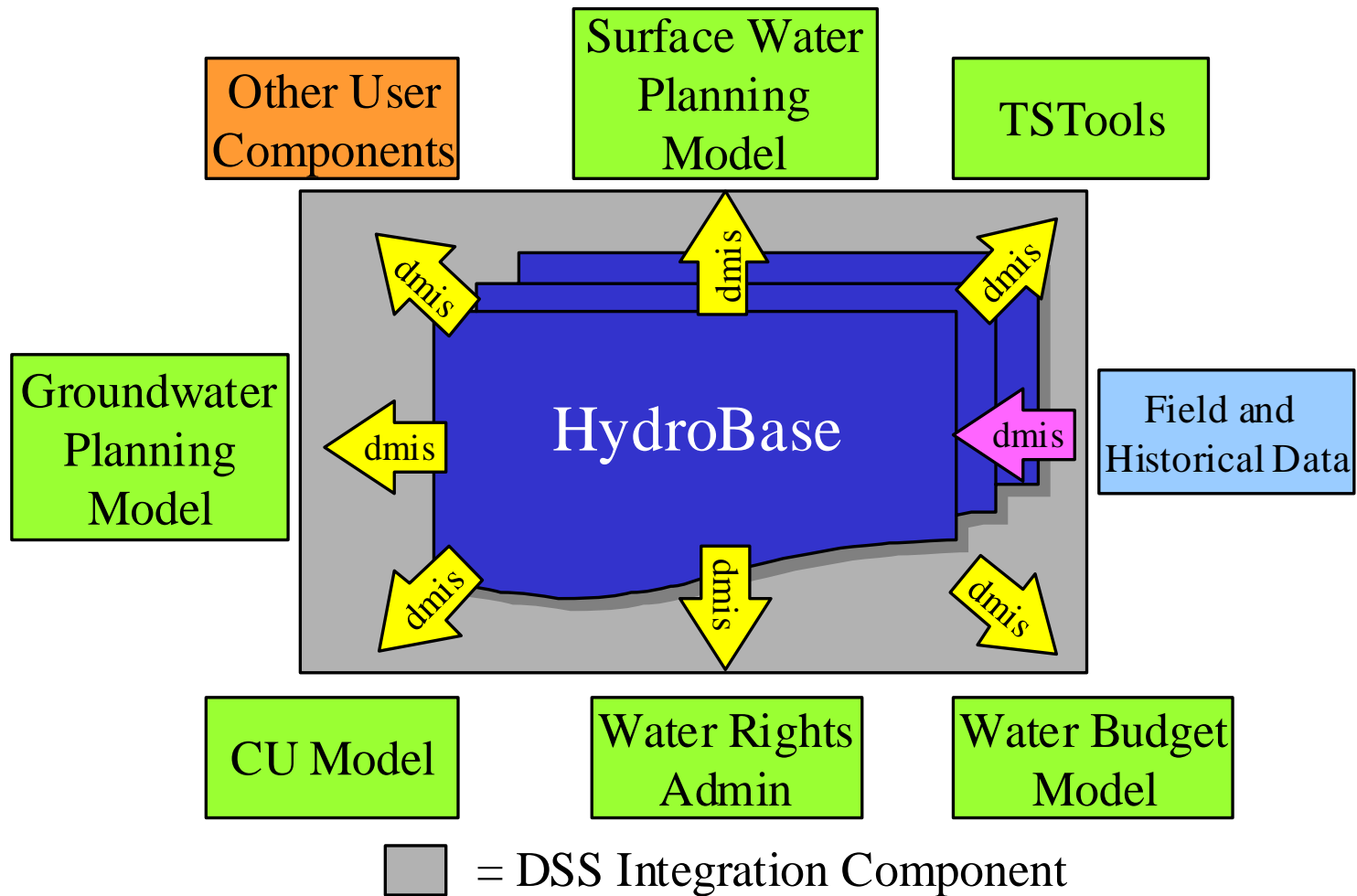
Colorado Water Conservation Board and Division of Water Resources

SPDSS

Major Components

- ◆ Data - Tabular and Maps
 - ◆ New Data - Irrigated Lands, stream gages, aquifer data, and observation wells
 - ◆ Tools – CU, SW, GW
 - ◆ User Involvement
 - ◆ Documentation & Product Distribution
- 
- A stylized, layered mountain range graphic in shades of teal and blue, located in the bottom right corner of the slide.

DSS Components



Tabular Data

- ◆ Stations
 - Streamflow
 - Climate (temp, ppt., evap.)
- ◆ Structures
 - Diversions
 - Reservoirs
 - Instream Flows
- ◆ Water Rights
 - Transaction
 - Net
- ◆ Ground Water
 - Water Levels
 - Pumping Tests
- ◆ Calls
 - Tributary
 - Mainstem
- ◆ Other
 - Agricultural Statistics
 - Crop Growth Coefficients

Tabular Data Internet (WWW)

Colorado's Decision Support Systems - Microsoft Internet Explorer

Address: <http://cdss.state.co.us/DNN/ViewData/StructuresDiversions/tabid/75/Default.aspx>

Colorado's Decision Support Systems
Developed by DWR and CWCB

Home Overviews Basin View Data Map Viewer Products

Structures (Diversions)

Water Division/District: 1 - South Platte: Greeley to Balzac
Structure Type: 1 - Ditch
Last Refresh Date: 2007-07-01

Structure Name Structure ID Source Legal Location Decreed Amounts Owner Name Case Number

Decree Type: Decreed Rate (abs) Operator: > Value: 500.0000

Submit Request

Select a row from the search results below to activate the reporting features

	Div	WD	Structure ID	Structure Name	Q10	Q40	Q160	Sect	Twshp	Range	PM	Distance From N/S Line	Distance From E/W Line	Water
	1	1	518	LOWER PLATTE BEAVER D	NW	NE	SE	25	4N	57W	S	1790 S	1080 E	SOUTH PL
	1	1	513	JACKSON LAKE INLET DITCH	SE	NE	SW	18	4N	61W	S	750 S	1500 E	SOUTH PL
	1	1	514	FT MORGAN CANAL	SE	NE	SE	31	5N	59W	S	1380 S	920 E	SOUTH PL
	1	1	501	EMPIRE DITCH	SE	SW	SW	19	5N	63W	S	275 S	1350 W	SOUTH PL
	1	1	507	BIJOU CANAL			NE	13	4N	63W	S	650 N	100 E	SOUTH PL
	1	1	503	RIVERSIDE CANAL		SW	SW	20	5N	63W	S	600 S	350 W	SOUTH PL

9 records returned

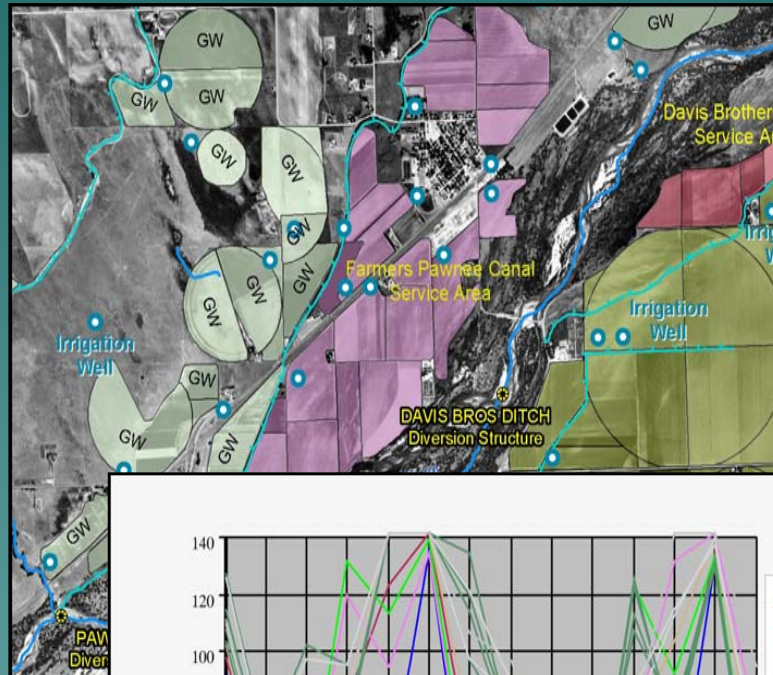
Results List Report: Structure Reports:

Spatial (Map) Data

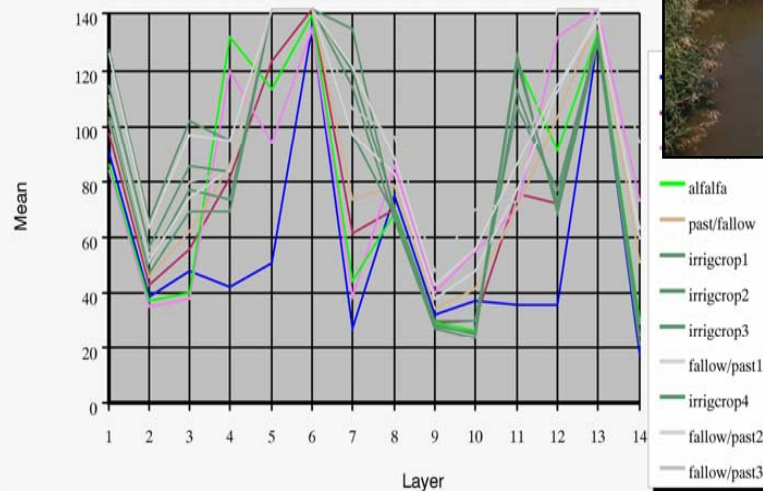
- ◆ Basemap
 - Hydrology
 - Roads
 - Cities and Towns
 - Public Land Survey (T-R-S)
- ◆ Stations
 - Diversions
 - Reservoirs
 - Instream Flows
 - Climate
- ◆ Irrigated Acreage
 - Water Source
 - Crop Type
 - Irrigation Method
- ◆ Other
 - Average precipitation
 - Average evaporation
 - Canals
 - Drains

Spatial Data

Irrigated Acreage Mapping



**Irrigated Area,
Crop Type,
Irrigation Method,
Water Supply**

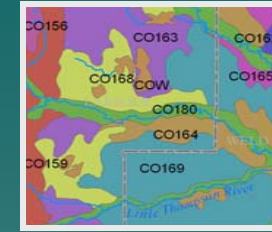


Consumptive Use StateCU

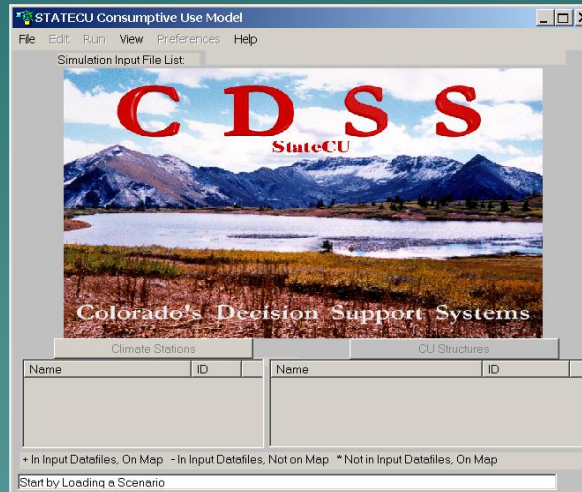
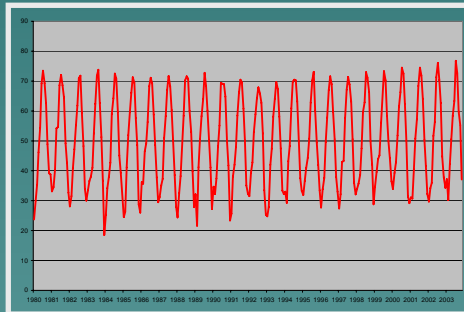
Irrigated
Acreage
and Crop
Type



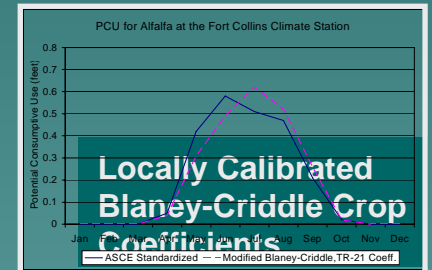
Soil
Data



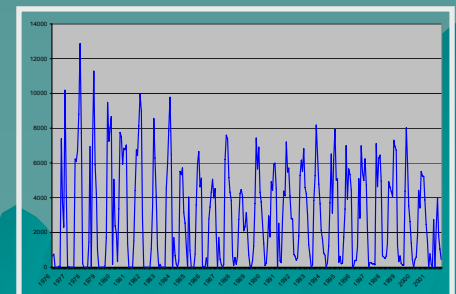
Climate Data



Locally Calibrated
Blaney-Criddle Crop
Coefficients

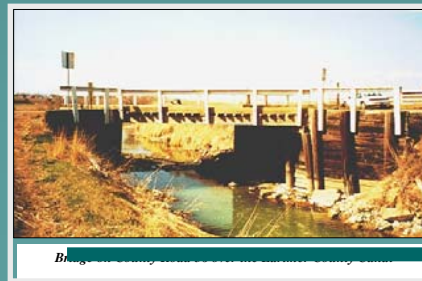


Surface Water Supply Data



PARCEL	CROP_TYPE	IRRIGATION	ACREAGE	PERIMETER
10101	Alfalfa	Sprinkler	131.832	2610.943
10102	Corn	Flood	135.253	2650.783
10103	Alfalfa	Sprinkler	124.643	3103.069
10104	Corn	Sprinkler	123.794	2532.175
10105	Corn	Flood	133.197	2619.833
10106	Small Grains	Sprinkler	135.335	2649.933
10107	Alfalfa	Flood	134.877	2637.105
10108	Alfalfa	Flood	134.181	2637.852
10109	Small Grains	Flood	125.197	2542.805
10110	Alfalfa	Sprinkler	122.907	2521.061

Irrigation Method

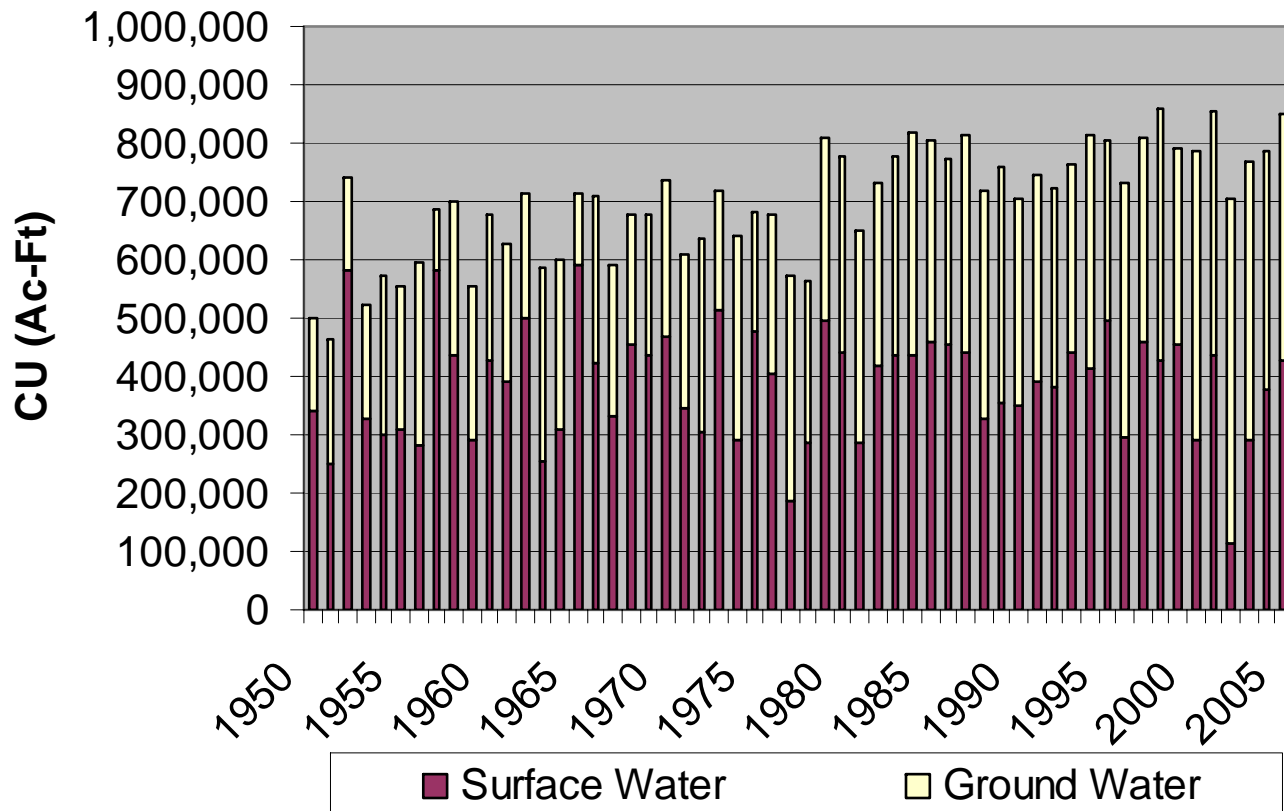


Ditch Efficiencies

StateCU Typical Results

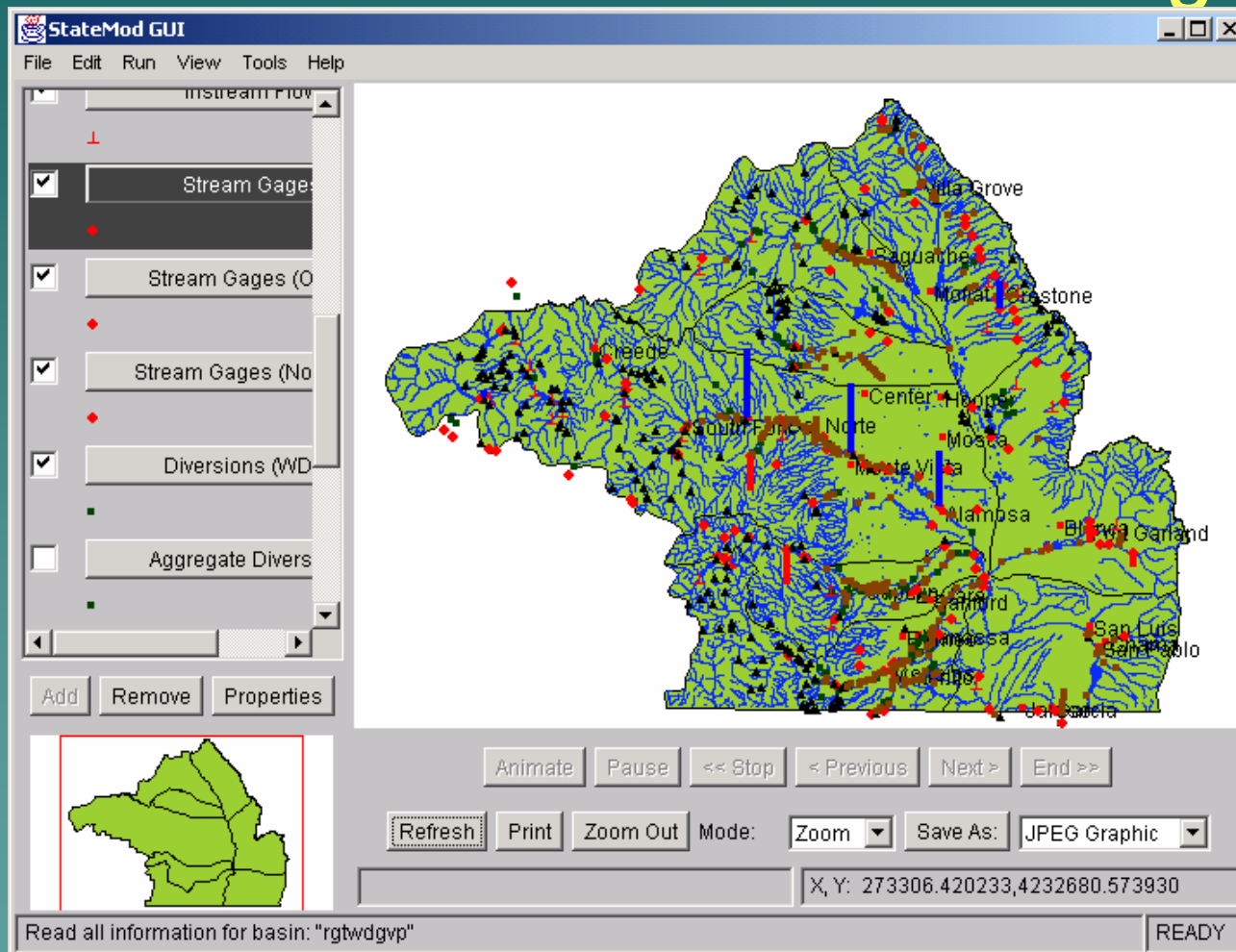
CU by Water Supply (SW and GW)

Figure 5
Phase 5 CU by Water Supply



StateMod

Colorado's Water Resources Planning Model



Ray Bennett, Colorado Division of Water Resources

StateMod Major Features

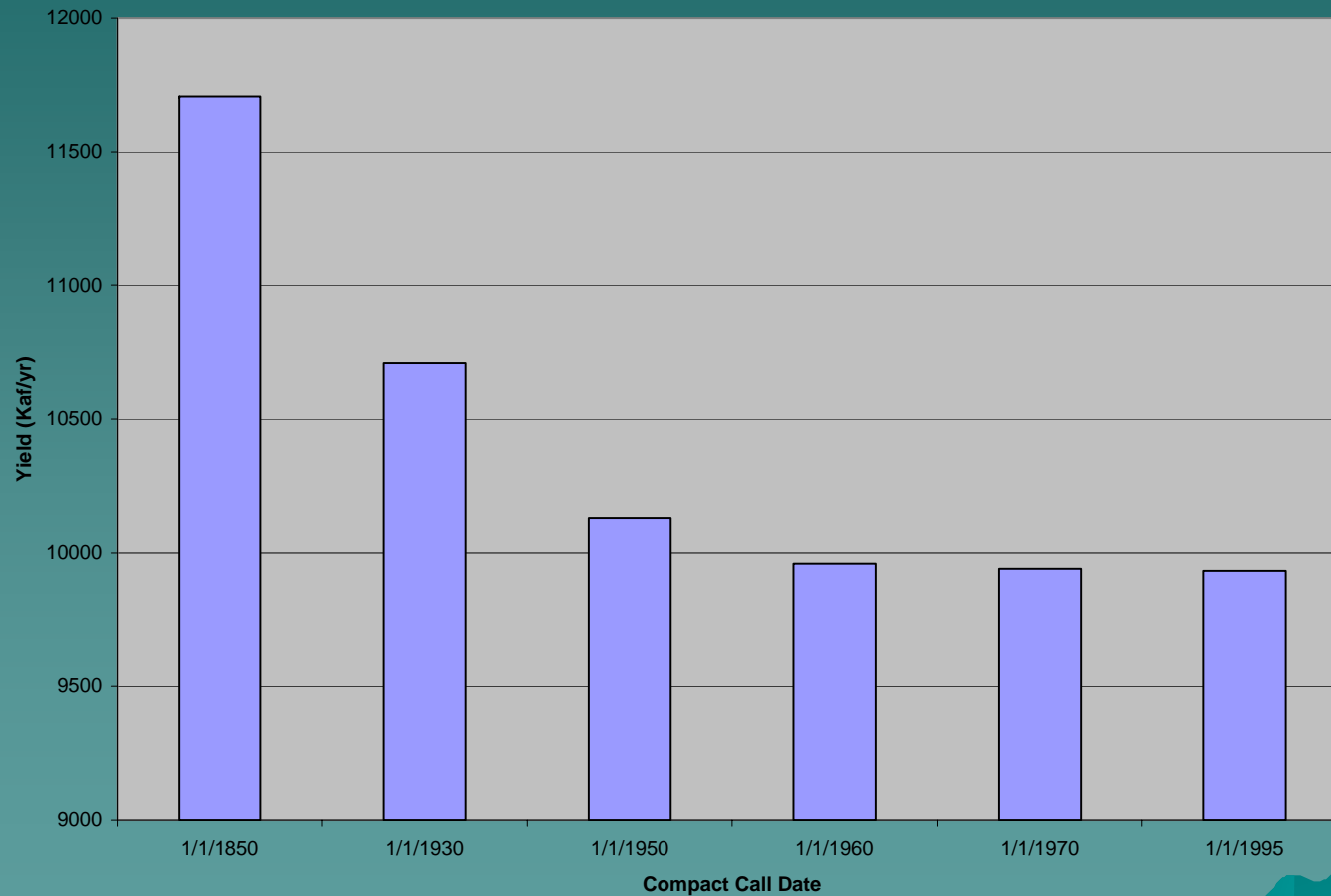
- Network System
 - Monthly or Daily Time Step
 - Prior Appropriation Doctrine
 - Structure Types
 - Diversions, Reservoirs,
Instream Flows, Wells &
Plans
 - Operational Rules
 - Complex water operations
 - Graphical User Interface
- 
- A stylized, dark teal silhouette of a mountain range is positioned in the bottom right corner of the slide, partially overlapping the background gradient.

StateMod Features (cont.....)

- Creates Base or Natural Flows
 - Efficient Solution Method
 - Direct Solution Algorithm
 - Modified Direct Solution Algorithm
 - Variable Efficiency
 - Soil Moisture Accounting
 - Plan Accounting
 - Call Reporting
- 
- A stylized, layered mountain range graphic in shades of teal and blue, located in the bottom right corner of the slide.

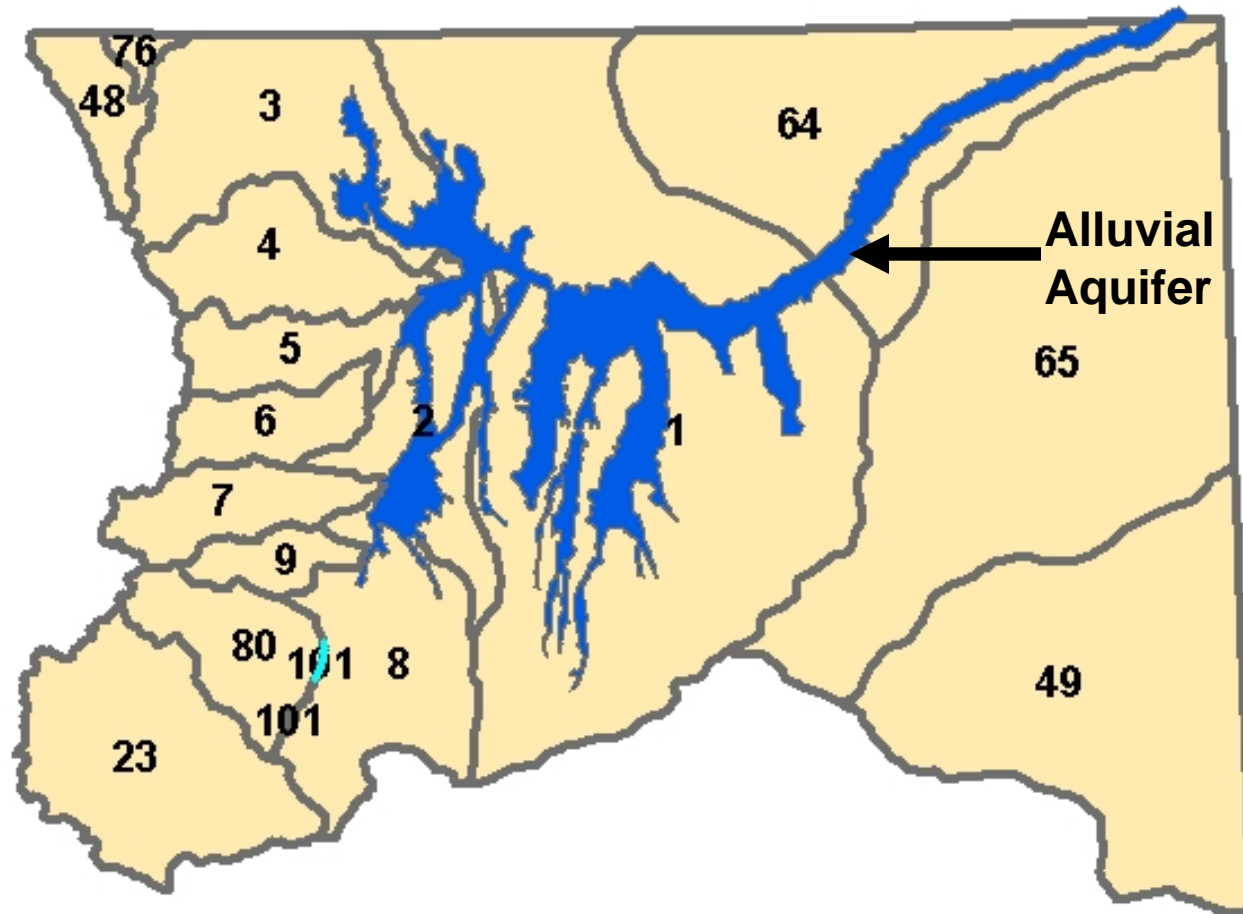
StateMod Typical Results

Compact Delivery Vs Compact Call




Colorado's Ground Water Model

Modflow (USGS)

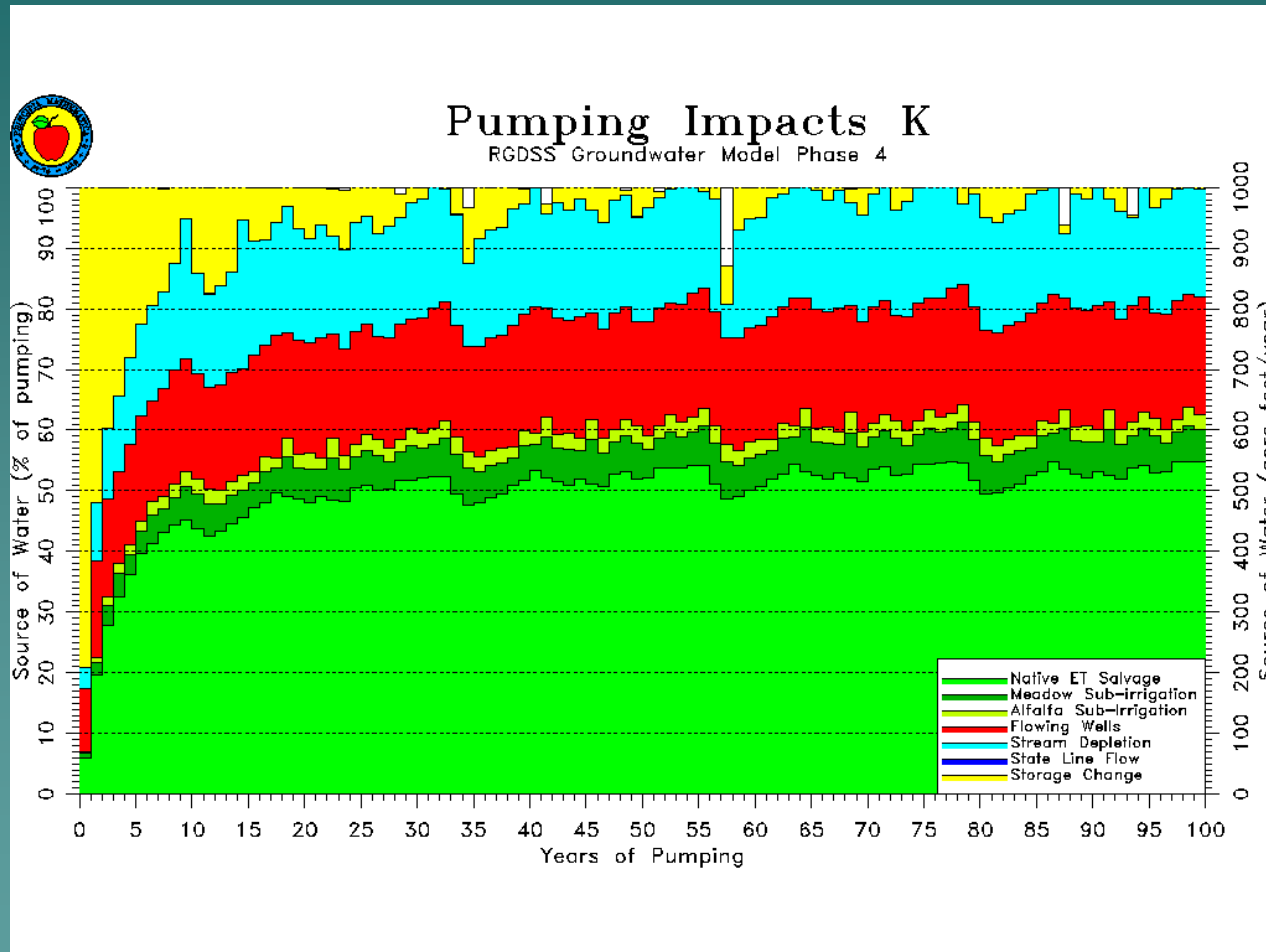


Modflow Features

- ◆ Geology
 - ◆ Aquifer Parameters
 - ◆ Pumping
 - ◆ Recharge
 - ◆ Boundary Conditions
 - ◆ Streamflows and Diversions
 - ◆ Springs
 - ◆ Drains
 - ◆ Evapotranspiration
 - ◆ Subirrigation
- 
- A stylized, layered mountain range graphic in shades of teal and blue, located in the bottom right corner of the slide.

Modflow Typical Results

Proposed Pumping Impact



More about SPDSS

- ◆ *Web Site*

- <http://cdss.state.co.us>

- ◆ *DWR*

- Ray Bennett (303) 866 - 3585

- ray.bennett@state.co.us

- ◆ *CWCB*

- Ray Alvarado (303) 866 - 3517

- ray.alvarado@state.co.us